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Umbilical artery Doppler velocimetry in the prediction of intrapartum fetal compromise

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Summary

The value of early intrapartum umbilical artery Doppler velocimetry in the prediction of fetal compromise was studied. One hundred patients were recruited into the study and fetal compromise was diagnosed by abnormal first- or second-stage fetal heart rate traces, a 5-minute Apgar score less than 7, or the development of hypoxic ischaemic encephalopathy. Fetal compromise developed in 30 patients. An umbilical artery resistance index (RI) of 0,66 or less did not predict fetal compromise (sensitivity 13%, specificity 89%, positive predictive value 25%, negative predictive value 70%). Since the mean umbilical artery RI was identical in the compromised and the non-compromised groups, we conclude that early intrapartum Doppler velocimetry is of very little clinical value in predicting fetal compromise at term.

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I ntrapartum monitoring of the viable fetus is imperative and the current choices available to the obstetrician are intermittent auscultation or continuous electronic fetal heart rate monitoring (CEFHRM), with or without fetal scalp blood sampling. A normal trace on CEFHRM indicates a greater than 95% probability of fetal well-being,[1] and when correctly used CEFHRM is a sensitive indicator of fetal compromise.[2] CEFHRM is only of actual benefit when fetal compromise occurs, and prediction early in labour of cases in which it is likely would allow optimal utilisation of limited resources.[3]

Doppler ultrasound has been widely reported as a non-invasive technique for studying changes in blood flow in the umbilical arteries. The velocity waveform obtained reflects downstream resistance to blood flow.[4] An increase in resistance results in decreased end-diastolic blood flow, which is reflected as diminished end-diastolic velocities in the waveform. Absent end-diastolic velocities (AEDVs) indicate severely increased placental resistance and are associated with high perinatal morbidity and mortality.[5] In these cases histological examination of the placenta demonstrates a decrease in the number of tertiary villi arterioles.[6] Antenatally abnormal umbilical artery waveforms precede abnormalities in the fetal heart rate pattern,[5,7,8] and a randomised controlled trial has shown that abnormal umbilical artery waveforms can predict pregnancies likely to be complicated by intrapartum asphyxia.[9] Doppler analysis of the umbilical artery waveform is feasible during labour.[10-12]

We studied umbilical artery waveforms in early labour to see whether we could identify those fetuses most likely to develop compromise and thus benefit from CEFHRM.

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Patients and methods

Women with singleton pregnancies, in early spontaneous labour (3 - 6 cm cervical dilatation) with cephalic presentation, who arrived in the labour ward at Tygerberg Hospital between 08h00 and 15h00 from Mondays to Thursdays, were asked to participate in the study. None refused, and 100 women were recruited from April to August 1990.

Umbilical artery velocity waveforms were obtained with a 4 MHz continuous-wave Doppler ultrasound instrument and analysed on a spectrum analyser (Doptek 9000; Doptek, Chichester, UK). All Doppler examinations were performed by one observer (G.R.H.). A 200 Hz thump filter was used to eliminate the low frequencies obtained from movements of the arterial wall. The umbilical artery waveform was obtained transabdominally between uterine contractions and after the fetal heart rate (FHR) had returned to the baseline, with the patient in the left lateral position and the hand-held continuous-wave transducer adjusted to obtain the best umbilical signal identified by its characteristic appearance. Recordings of the waveforms were taken only when the pattern was stable, indicating fetal apnoea and the absence of fetal activity. Once a steady signal had been obtained, the Doppler signal was frozen and the resistance index (RI) (peak systolic – end-diastolic Doppler shift/peak systolic Doppler shift)[13] was measured in five consecutive waveforms and the mean result calculated. A RI of 0,66 or higher was considered to be abnormal.[14,15] Information obtained from the Doppler flow studies was not made available to attending medical personnel.

The FHR was monitored continuously with an abdominal ultrasound transducer or a fetal scalp electrode, during the first stage of labour in all patients and during the second stage in the 76 who delivered vaginally. All patterns were retrospectively evaluated by a single experienced observer (R.C.P.) who was unaware of the Doppler data, intrapartum course and neonatal outcome. Each FHR pattern was assessed separately in the first and second stage of labour. First-stage patterns were classified as reassuring, non-reassuring, suspicious or ominous, according to objective criteria.[16] Second-stage patterns were classified according to objective criteria as either normal or ominous.[17]

Neonates were initially assessed by means of the Apgar score at birth and at 5 and 10 minutes. Neurological assessment for signs of hypoxic ischaemic encephalopathy (HIE)[18] was performed on them all within the first 48 hours by a single observer (G.K.) who was unaware of the Doppler velocimetry results, intrapartum data or Apgar score.

Fetal compromise was diagnosed in the first stage of labour when suspicious or ominous FHR patterns persisted sufficiently long (in spite of measures such as discontinuation of oxytocin, turning the mother onto her left side, and administration of oxygen) to warrant fetal scalp blood sampling or operative delivery (as defined by Murphy et al.[2]). Fetal compromise was diagnosed neonatally in any infant with a 5-minute Apgar score less than 7[19] or who developed HIE.

Statistical analysis was performed using the χ^2-test for categorical data, Fisher's exact test if the expected value was less than 5 in one of the cells, and an unpaired Student's t-test for normally distributed continuous variables. A P-value of less than 0,05 was considered significant.

The study was approved by the Tygerberg Hospital Ethics Committee and all patients gave informed consent before entry into the study.

Intrapartum and neonatal data divided the patients into two groups, 30 cases in which fetal compromise occurred and the remaining 70 cases in which it did not. Table I sets out the specific combination of factors used to identify the 30 patients in the fetal compromise group as well as their mean RIs; in this group 11 caesarean sections were performed due to abnormal first-stage FHR patterns, and 1 caesarean section, 5 forceps deliveries and 3 vacuum extractions were performed in the second stage due to FHR abnormalities. Table II compares characteristics of the two groups and shows that maternal age, birth weight and gestational age were similar. Fig. 1 shows that the umbilical artery RI (mean and distribution) was also similar.

TABLE I.

Criteria used to allocate 30 fetuses to the fetal compromise group and their mean RIs

Reason for diagnosis of fetal compromise	No.	RI (mean ± SD)
Abnormal 1st-stage FHR pattern	19	0,53 ± 0,07
Abnormal 2nd-stage FHR pattern	4	0,61 ± 0,11
5-minute Apgar score < 7	1	0,64
Abnormal 1st-stage FHR pattern and 5-minute Apgar score < 7	5	0,56 ± 0,06
Abnormal 1st-stage FHR pattern and HIE	1	0,41
Total	30	0,54 ± 0,0

TABLE II.

Details of the fetal compromise and no fetal compromise groups

	No fetal compromise (N = 70)	Fetal compromise (N = 30)
Maternal age (yrs) (mean ± SD)	24,3 ± 5,9	25,6 ± 5,5
Gestational age (wks) (mean ± SD)	38,4 ± 2,4	38,5 ± 1,9
Birth weight (g) (mean ± SD)	3,04 ± 0,57	2,93 ± 0,41
Meconium-stained liquor	9 (13%)	12 (40%)*
Prolonged labour (first stage)	7 (10%)	10 (33%)*
Opiate or epidural analgesia	36 (51%)	19 (63%)
Oxytocin administered	19 (27%)	11 (37%)
Caesarean section	12 (17%)	12 (40%)*
Assisted delivery†	5 (9%)	8 (44%)*
Umbilical artery PI (mean ± SD)	0,91 ± 0,24	0,94 ± 0,24
Umbilical artery RI (mean ± SD)	0,54 ± 0,08	0,54 ± 0,08

* $P < 0,02$.
† Excluding those cases delivered by caesarean section.
PI = pulsatility index.

Results

Early intrapartum umbilical artery Doppler velocimetry was easily performed on all 100 patients. The mean (± SD) maternal age, gestational age and birth weight were 25 ± 6 years, 38,5 ± 2,3 weeks and 3 008 ± 530 g respectively. The mean umbilical artery RI was 0,55 ± 0,08 (range 0,32 - 0,78). There was no case of absent or reversed end-diastolic flow.

The umbilical artery RI was greater than 0,66 in 12 patients; 4 of these developed fetal compromise, but so did 26 of the remaining 88 patients with a normal RI ($P = 0,512$). The sensitivity of the test in predicting fetal compromise was 13%, the specificity 89%, the positive predictive value 25% and the negative predictive value 70%.
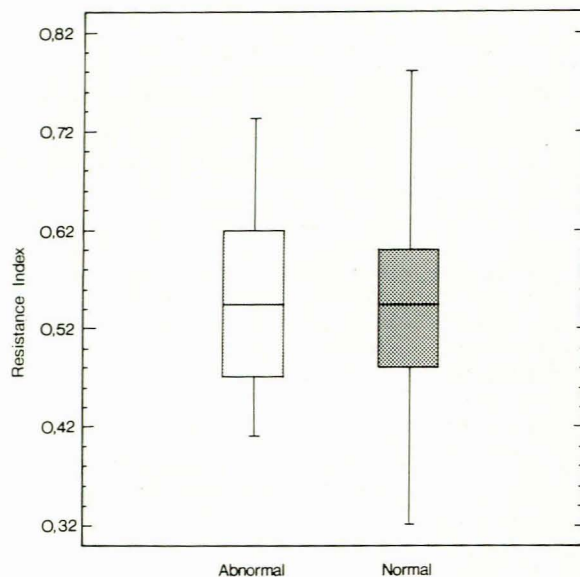
FIG. 1.
Umbilical artery RI (mean, SD and range) in the fetal compromise (abnormal) and no fetal compromise (normal) labour groups.

Discussion

The study confirms that umbilical artery Doppler studies are feasible during early labour and cause no discomfort to the patient. Doppler signals of good quality were obtained in all 100 patients, giving objective data available for immediate interpretation.

The pulsatility index, A/B ratio and RI are the most commonly used indices to describe the flow velocity waveforms in obstetrics.[20] We utilised the RI for data presentation; however, when analysed the other two indices gave similar results.

Inherently, neither the sensitivity nor the specificity of a test is superior, and their relative importance is dependent on the clinical situation. However, in the prediction of fetal compromise sensitivity is of greater importance.[21] The sensitivity and specificity of a test is dependent on the threshold value that distinguishes normal from abnormal. The poor sensitivity of 13% may be the result of the incorrect choice of 0,66 as the threshold value for umbilical artery RI, or the inability of Doppler velocimetry to predict fetal compromise. Fig. 1 shows that the mean umbilical artery RIs in the fetal compromise group and the normal labour group are identical; we therefore conclude that Doppler velocimetry in early labour does not predict fetal compromise, explaining the poor sensitivity of the test.

It is possible that the only finding of significance when using Doppler velocimetry is AEDV.[5,22,23] In our study no such patients were identified. This could be due to systematic error (where all the patients with AEDV were missed because of the system used to collect the patients); however, a more likely explanation is that AEDV is rare at term. Our experience is that AEDV is seldom reported after 34 weeks' gestation, probably because the fetus with AEDV usually has severe growth retardation progressing to intra-uterine death if intervention does not occur. Despite the fact

that no fetus in the study had AEDV, 30 fetuses manifested compromise and may have benefited from continuous FHR monitoring.

Doppler-derived umbilical arterial waveforms may have a role to play in the antepartum assessment of the high-risk pregnancy and the prediction of complications; however, we found that when performed early in labour, Doppler velocimetry did not identify the full-term fetus at risk of developing compromise.

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